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INVITED REVIEW

New techniques for wound debridement

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Abstract

Debridement is a crucial component of wound management. Traditionally, several types of wound debridement techniques have been used in clinical practice such as autolytic, enzymatic, biodebridement, mechanical, conservative sharp and surgical. Various factors determine the method of choice for debridement for a particular wound such as suitability to the patient, the type of wound, its anatomical location and the extent of debridement required. Recently developed products are beginning to challenge traditional techniques that are currently used in wound bed preparation. The purpose of this review was to critically evaluate the current evidence behind the use of these newer techniques in clinical practice. There is some evidence to suggest that low frequency ultrasound therapy may improve healing rates in patients with venous ulcers and diabetic foot ulcers. Hydrosurgery debridement is quick and precise, but the current evidence is limited and further studies are underway. Debridement using a monofilament polyester fibre pad and plasma-mediated bipolar radiofrequency ablation are both very new techniques. The initial evidence is limited, and further studies are warranted to confirm their role in management of chronic wounds.

Introduction

Debridement is the removal of necrotic tissue and foreign body from the wound to expose the underlying viable tissue in an effort to promote and expedite wound healing. It forms an important component of the wound bed preparation in the management of chronic wounds (TIME framework) (1–4). Debridement helps to reduce the bacterial burden within the wound, controls on-going inflammation and malodour, and encourages formation of granulation tissue (5).The molecular and cellular environment of chronic wounds should be converted to resemble that of acute wounds to allow rapid healing, and for this to occur non healing wounds may require repeated debridement (2).

Various types of wound debridement techniques are currently available in clinical practice such as autolytic, enzymatic, biodebridement, mechanical, conservative sharp and surgical (6–8). Autolytic debridement, which is body's natural response to necrotic tissue, is painless and selective, but the process is slow and can take a long time to be effective (9). Enzymatic debridement, such as collagenase-based dressings, has been suggested as an alternative method, and is useful when other techniques are not feasible during the initial management of a chronic wound (10). Over the last decade,

Key Messages

- various new wound debridement techniques have been introduced, but further evidence is required before these can be more widely accepted in clinical practice
- high frequency ultrasound therapy does not seem to improve ulcer healing rates, but there is some evidence to suggest that low frequency ultrasound therapy may promote healing in patients with venous ulcers and diabetic foot ulcers
- hydrosurgery debridement is quick and precise, but the evidence is limited and further studies are underway
- debridement using a monofilament polyester fibre pad and plasma-mediated bipolar radiofrequency ablation are both very new techniques. The initial evidence is limited, and further studies are warranted to confirm their role in management of chronic wounds

biodebridement using maggots has become increasingly popular. Larval therapy can be highly selective and rapid, but often needs to be combined with other forms of debridement after initial larval application (11,12). Mechanical (wet to dry) debridement has been used, but it damages healthy granulation tissue, and can be painful and time-consuming (13). Conservative sharp and surgical debridement, the current gold standard against which other forms of therapy are measured, are quick and effective techniques, but require a competent practitioner with specialist training and can be expensive; particularly, surgical debridement with the associated need of operation theatre time and hospital admission (13).

The method of choice for a particular wound depends on various factors such as type, size and position of wound, quantity and character of the exudate, patient tolerance, cost-effectiveness and available expertise and equipment. Often more than one type of debridement is required to achieve complete debridement. For many wounds debridement is an on-going process with slough and biofilm re-accumulating on the wound bed. The term maintenance debridement describes the process of periodic removal of this recurrent slough and may involve the re-application of one or more of the techniques described or the use of alternative debridement techniques such as autolytic or larval debridement. Several new techniques of debridement have been developed such as ultrasonic, hydrosurgery and mechanical debridement using an active debridement pad (14). The purpose of this review was to critically evaluate the current evidence behind the use of these newer techniques in clinical practice.

Search strategy

A systematic review of electronic databases PubMed and Google Scholar was undertaken. Literature search was conducted on 4 May, 2012. PubMed was reviewed using the MeSH search terms: Initially, new AND methods OR techniques AND wound AND debridement; and secondly, ultrasound OR hydrosurgery OR debrisoft OR plasma-mediated bipolar radiofrequency ablation AND wound AND debridement OR healing. Google scholar was reviewed using all of these terminologies as search terms. In addition, references of all relevant papers identified from these databases were examined for any related publications.

Ultrasound

Use of ultrasound therapy for wound healing has been extensively investigated. There are mainly two classified effects of ultrasound on tissue: thermal and non thermal (15). Both these effects are inseparable, but their respective proportions vary with the frequency and intensity of ultrasound. Thermal effects are predominant with high frequency (MHz) and intensity (W/cm^2) ultrasound, which raises tissue temperature and possibly enhances blood flow. Low frequency ultrasound (kHz) has predominantly mechanical (non thermal) effects, namely cavitation and acoustic streaming, although there are some thermal effects on tissue (15,16). Low frequency ultrasound can be high intensity (~50 W/cm^2) delivered with direct contact with the wound or low intensity (0·25–0·75 W/cm^2) delivered without direct contact with wound bed; both are used with saline as coupling media between the ultrasound probe and wound bed. High intensity ultrasound debrides necrotic tissue possibly because of the cavitational effect produced by rapid expansion and implosion of gas bubbles within tissue fluid or coupling media (16). Whereas low intensity ultrasound may promote wound healing predominantly by acoustic streaming effects such as increased protein synthesis and production of growth factors (17). In addition, low frequency ultrasound has been reported to have anti-bacterial effects (18,19), and enhance fibrinolysis in vitro (20,21).

Ultrasound therapy should only be administered in a dedicated wound clinic treatment room, which should be decontaminated according to the local infection control policy. The clinician must wear protective clothing such as fluid-proof gown, face shield, gloves and hair cover. The patient should also wear face mask during the treatment. These precautions are crucial to prevent aerosol inhalation and spread of microbes beyond the wound clinic treatment room (17).

In clinical practice, therapeutic ultrasound has been used on patients with leg ulcers of various aetiologies, and reported to have variable results. Peschen *et al*. reported use of low frequency (30 kHz), low intensity (0·1 W/cm^2) ultrasound therapy in chronic venous leg ulcer patients compared to standard wound care alone (22). Although this was a small study with only 12 patients in each arm, they reported a significant reduction in the mean ulcerated area after 12 weeks of therapy. Ennis *et al*. compared low frequency (40 kHz) non contact ultrasound to placebo in 55 diabetic patients with recalcitrant foot ulcers in a randomised, multicentre, double-blinded study (23). At 12 weeks, they reported significantly higher healing rates in the treatment group. Kavros *et al*. reported similar results in patients with leg ulcers associated with chronic critical limb ischaemia (24). They compared non contact, low intensity (0·1–0·8 W/cm^2), low frequency (40 kHz) ultrasound combined with standard wound care in 35 patients to standard wound care alone in a similar number of patients. The same group published another study on 163 patients with chronic lower extremity wounds (25). Within the limitations of a retrospective study, they reported significantly higher percentage of wounds healed with low intensity and low frequency ultrasound compared to standard care alone. A recent meta-analysis reported significantly improved complete healing rates with low frequency and high intensity ultrasound (20–30 kHz, 50–60 W/cm^2) compared to sharp debridement at three and five months, but no difference at six months (26). The studies included patients with chronic venous ulcers and diabetic foot ulcers. However, there were only two studies suitable for the meta-analysis, and the overall numbers were small ($N = 116$). The same study reported improved healing rates with low frequency and low intensity ultrasound (20–30 kHz, 0·1–0·5 W/cm^2) compared to placebo at three months in patients with diabetic foot ulcers and venous ulcers. Results of two studies were pooled, and even so the total number of patients was small ($N = 77$). A recent systematic review pooled results from six randomised controlled trials (RCTs) examining the effects of high frequency ultrasound (1 MHz) in patients with venous ulcers (27). Overall, there was no statistically significant difference in healing rates with use of ultrasound, however the quality of individual studies was poor and there was a high risk of bias. A large multi-centre RCT was conducted in the UK comparing high frequency ultrasound (1 MHz, 0·5 W/cm^2) administered weekly for 12 weeks combined with standard therapy compared to standard therapy alone in the treatment of venous leg ulcers (28). There was no evidence found to suggest that such ultrasound therapy improved ulcer healing rates. This was a well conducted study with good randomisation technique and concealed treatment allocation with a power of 90%, thus minimising the risk of bias, and hence the evidence can be regarded as robust, however, this study included only one ultrasound regime (high frequency ultrasound delivered weekly). The previously referenced smaller studies, which suggest ultrasound may improve healing rates, examined low frequency ultrasound delivered thrice weekly.

We found limited evidence for the efficacy of therapeutic ultrasound for wound debridement. Ramundo and Gray reported similar findings in their review (29). Stanisic *et al*. reported effective debridement of adherent fibrin from wound surfaces in their limited series of three patients (17). The studies that we appraised reported the effects of ultrasound on wound healing rather than wound debridement. There is good evidence to suggest that high frequency ultrasound therapy does not improve ulcer healing rates, but there is some evidence in favour of low frequency ultrasound therapy especially in patients with venous ulcers and diabetic foot ulcers. Further well-designed and adequately powered studies are required to examine the role of low frequency ultrasound and the treatment schedule, and particularly to evaluate the effectiveness of ultrasound for wound debridement. A single centre RCT comparing low frequency ultrasound to sharp debridement has been recently completed (NCT01237392), but the results are still awaited.

Hydrosurgery

A hydrosurgery system has been developed by Hydrocision of Andover (USA), and brought into clinical practice by Smith and Nephew Medical Limited (Hull, UK) (30). It works on the principle of Venturi effect. Sterile saline flows to the console where it is pressurised, and forced through a tiny jet nozzle at the end of a hand piece to produce a high-velocity stream, which passes back into an evacuation collector. This creates a localised vacuum, which simultaneously grasps, cuts and removes the debris from the wound. Different power levels are available that can be changed depending on the tissue being debrided. In addition, the cutting effects can also be manipulated by adjusting hand piece orientation and pressure. The suggested advantages are that hydrosurgery debridement is rapid and cost-effective, and is focussed to precisely debride necrotic tissue whilst sparing the viable tissue. Although it can be used in all clinical settings, to prevent aerosol contamination the clinician must don appropriate personal protective equipment and local infection control policies should be followed.

Mosti *et al*. compared use of hydrosurgery debridement to moist dressings in patients with vascular leg ulcers, caused by both arterial and venous disorders (31). They found that wound debridement using hydrosurgery was well tolerated, and that most patients were successfully treated at the bedside with or without local anaesthesia. Mean time to debride the wound was 5·8 minutes, and average time to obtain a clean wound was reduced by nearly 5 days. However, this study is at high risk of bias as it was not randomised. The term ‘clean wound’ is not well defined, and could be very subjective. In addition, hydrosurgery debridement was compared with autolytic debridement, when surgical debridement is considered to be the gold standard. Caputo *et al*. published a well conducted RCT comparing hydrosurgery debridement to conventional surgical debridement in patients with diabetic or venous leg ulcers (32). On an average, hydrosurgery debridement was quicker by nearly 7 minutes per procedure (10·8 minutes with hydrosurgery versus 17·7 minutes with conventional debridement), and required significantly less instruments and sterile saline. The median time for wound closure was similar in both groups. This study had good randomisation and allocation concealment, however, the overall numbers were small ($N = 22$ in hydrosurgery group, and $N = 19$ in conventional debridement group). Vanwijck *et al*. used hydrosurgery debridement in 167 wounds from 155 patients, mostly with vascular ulcers because of both arterial and venous conditions (33). There was no control group. They reported very precise control with hydrosurgery leaving a smooth wound surface, which allowed immediate skin grafting in the majority of patients. This study, although at high risk for bias, does agree with other studies regarding the cost effectiveness of hydrosurgery debridement, especially if immediate skin grafting is undertaken. However, an attempt to review the cost-effectiveness of hydrosurgery debridement was limited due to paucity of available data and poor quality of studies (34). A single centre RCT comparing hydrosurgery debridement to conventional surgical debridement in leg ulcers has recently been completed (NCT00521027), and another similar study is underway for treatment of acute and chronic surgical wound dehiscence (NCT01050673). The results of these studies may help to clarify the role of this therapy in wound debridement.

Monofilament polyester fibre pad

Monofilament polyester fibre pad (Activa Healthcare Ltd, Burton-upon-Trent, Staffordshire, UK) is a new product in the field of wound debridement. It is made of monofilament polyester fibres, and the available size of $10 \times 0\,cm^2$ consists of more than 18 million fibres (35). It is unique as it not only debrides the loose necrotic tissue, but also absorbs and binds the debris within its fibres. It is chemically inert, stable and mechanically strong, which prevents shedding when in contact with wound surface during debridement. To debride the wound, it is suggested to wet the pad in saline or antimicrobial solution, and gently wipe the wound using light pressure for 2–4 minutes.

So far a limited number of studies have been published examining the effects of the polyester fibre pad on various types of wounds. Haemmerie *et al*. reported clinical efficacy after single use of the pad for debridement of chronic leg ulcers of various aetiologies (36). This was a small prospective pilot study ($N = 11$), and there was no control group. Although the wound assessments were blinded, the study was at high risk of introducing bias. After a single debridement session, the polyester fibre pad was found to be effective in different types of wounds such as those with copious seropurulent discharge or dry wounds with necrotic layers. It scored highly in terms of ease of use and patient tolerability. Another study evaluated the efficacy of the polyester fibre pad in different types of wounds in need of debridement, following three sessions at interval of 4 days (37). This was a prospective, multi-centre study. Initial assessments were by healthcare professionals doing the debridement, and the photographs, pre and postdebridement, were then assessed by a blinded, independent clinician. They also compared these results to their experience with debridement using different modalities by selecting cases from their retrospective electronic database. Within the limits of a non randomised study with no simultaneous control group, they reported the polyester fibre pad to be an efficient debridement tool; more than 90% of wounds were reported to significantly improve following three sessions of debridement. The mean duration per procedure was only 2·5 minutes; significantly less compared with other techniques of debridement. Although whether the wounds, on which the different modalities of debridement were practised, were comparable is debatable. Nonetheless, they found the polyester fibre pad to be safe and well tolerated by patients. Gray *et al*. reported a case series of 18 patients with wounds of various aetiologies, where single treatment with the polyester fibre pad was used for debridement (38). Notwithstanding the bias possibly involved in this study, it reinforced the findings of previous reports. The authors suggested that the polyester fibre pad may be useful for debriding wounds with hyperkeratosis, haematomas or soft slough. For wounds with adherent slough or dry black necrotic tissue alternative modes of debridement such as surgical debridement may be necessary. The monofilament polyester fibre pad seems to be safe, well tolerated and can be used in community without any specialist training, however further studies to examine cost-effectiveness and assess complete wound healing are warranted.

Plasma-mediated bipolar radiofrequency ablation

Plasma-mediated Bipolar Radiofrequency Ablation (PBRA), commonly referred to as Coblation, has been suggested to be successful in wound debridement in the initial studies. It is a relatively new equipment for clinicians involved in treatment of chronic wounds, although its use has been well established in other fields of surgery such as faciomaxillary and ear, nose and throat surgery (39,40). PBRA technology involves application of bipolar radiofrequency current between two electrodes in saline, which creates focussed physical plasma by exciting the electrolytes within the saline. This plasma can break molecular bonds within the tissues at relatively low temperatures (40–70°C), and thus remove the necrotic tissue with minimal damage to normal healthy tissue (41). PBRA has been shown to have significant microbicidal effects compared to other methods of debridement in vitro, and in vivo in porcine models (42,43). A recent study reported PBRA as easy to use, safe and effective when used in the outpatient department on six patients with chronic leg ulcers (44). However, several of the procedures were combined with sharp debridement to achieve full debridement. Further studies are warranted to assess the application of PBRA for wound debridement.

Conclusion

Debridement is an expected and necessary component of wound management and underpins the concept of wound bed preparation. Debridement also forms a part of bacterial load management within a wound, and is therefore closely integrated into an on-going wound management strategy. The method of choice for debridement should be the one deemed most effective for the patient, particularly considering patient tolerance, and the wound depending upon its anatomical location and the extent of debridement required. Recently developed products are beginning to challenge traditional techniques such as sharp and autolytic debridement but further evidence is needed if these techniques are to be more widely adopted.

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